

WINTER OBAN

(ONCORHYNCHUS BAYESIAN ANALYSIS)
A STATISTICAL LIFE-CYCLE MODEL FOR
WINTER-RUN CHINOOK

SALMONID INTEGRATED LIFE-CYCLE
MODELS WORKSHOP

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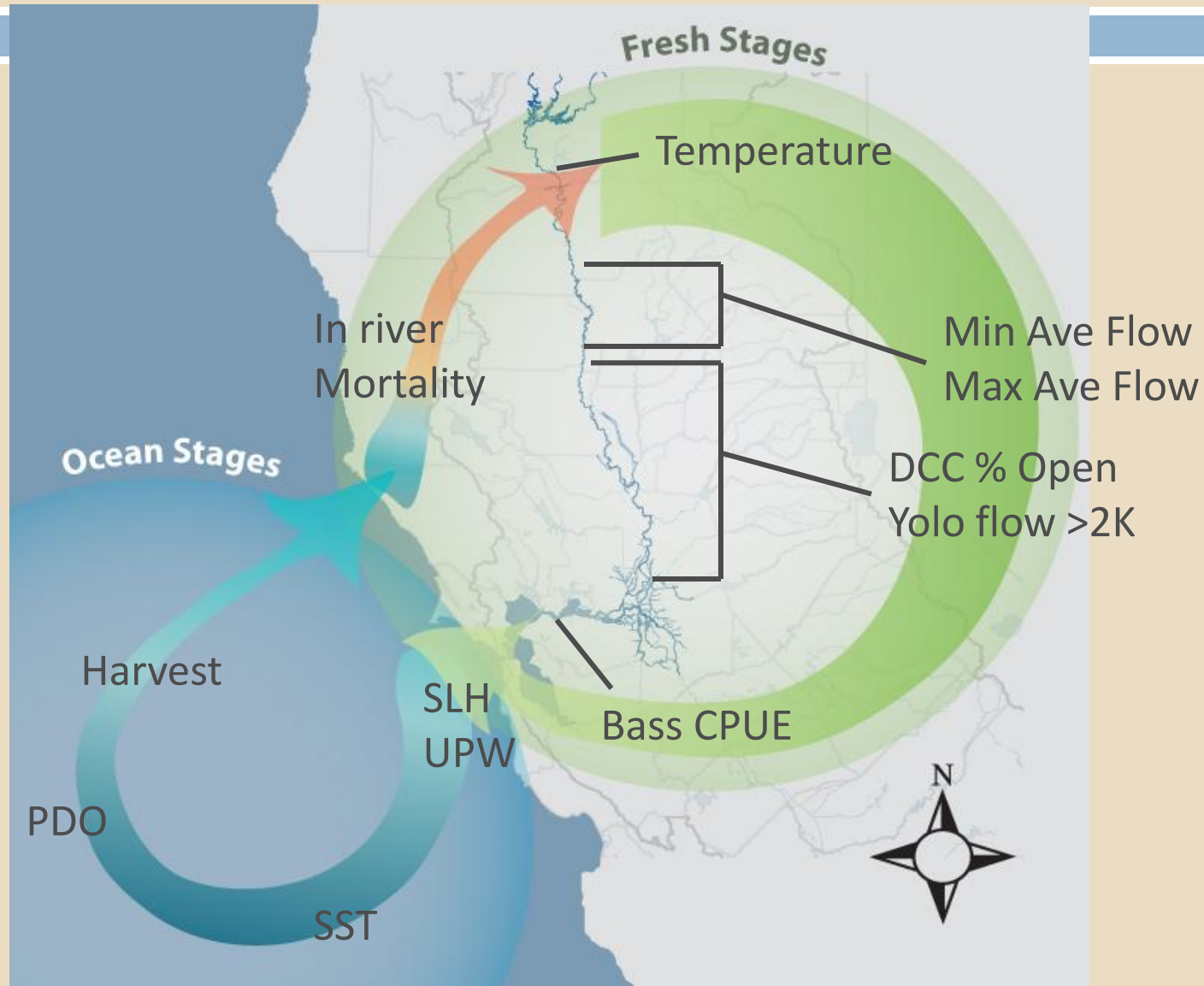
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Hypotheses regarding factors affecting WR population dynamics

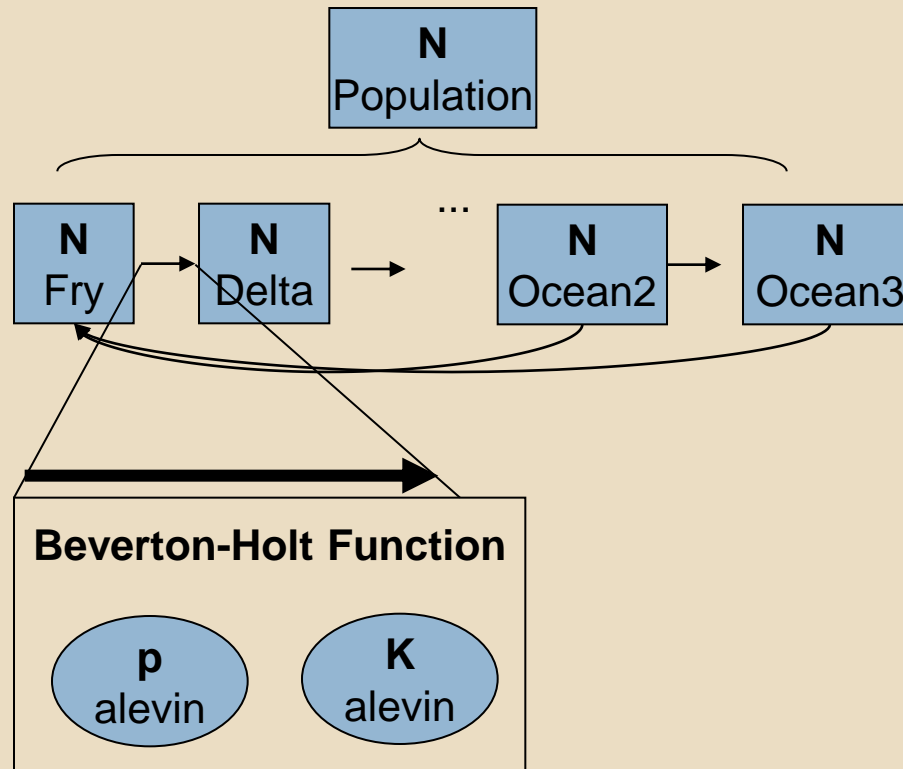


Objectives of OBAN

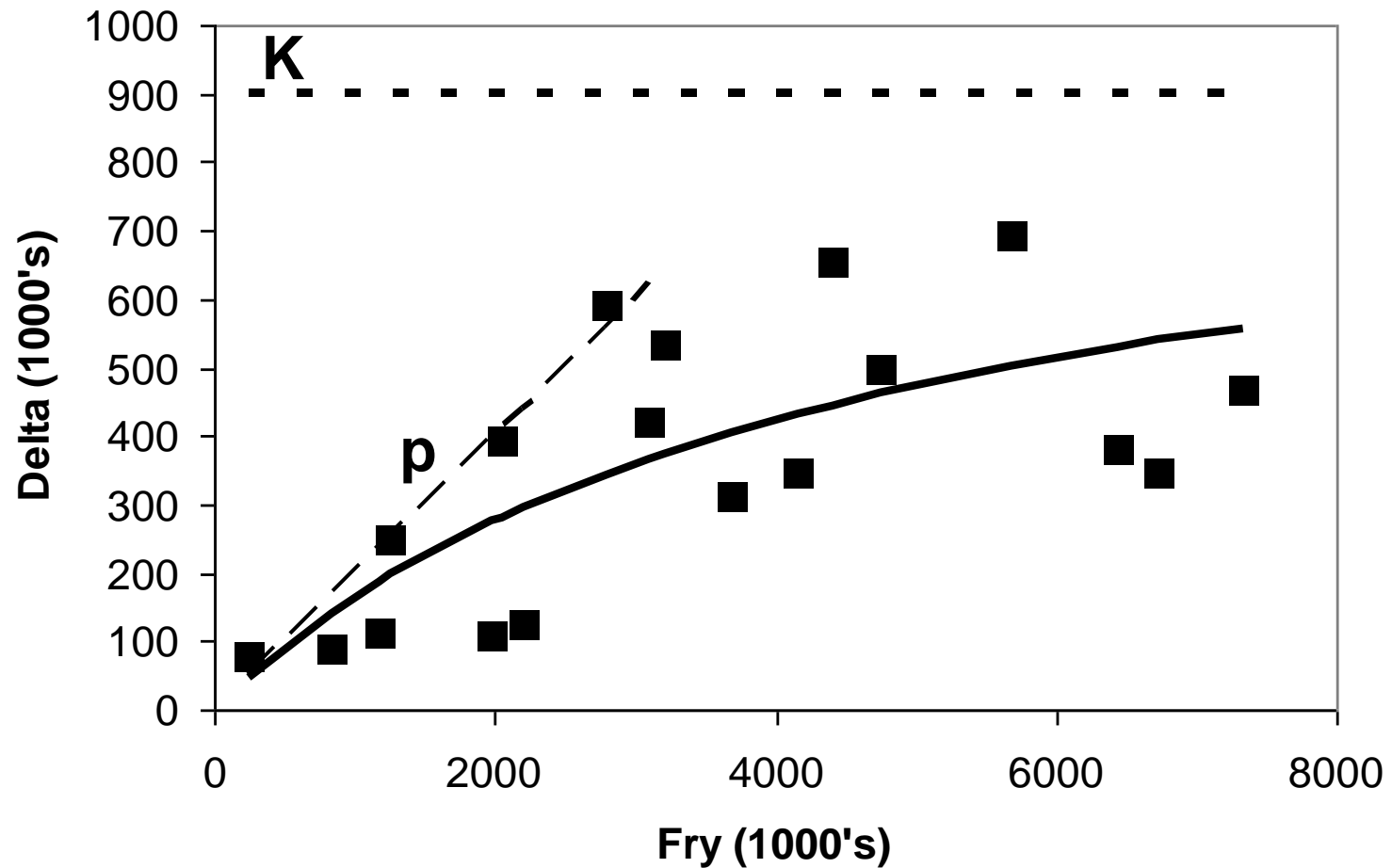
- Estimate population vital rates by statistically fitting predictions of the population dynamics model to observed indices of abundance
- Evaluate factors that may explain dynamic vital rates through the entire life-cycle, in particular near-shore and oceanic indices of productivity
- Explicitly incorporate uncertainty in the estimation procedure by using a Bayesian framework.



1st Hierarchy: Stage Transitions



Beverton-Holt Function



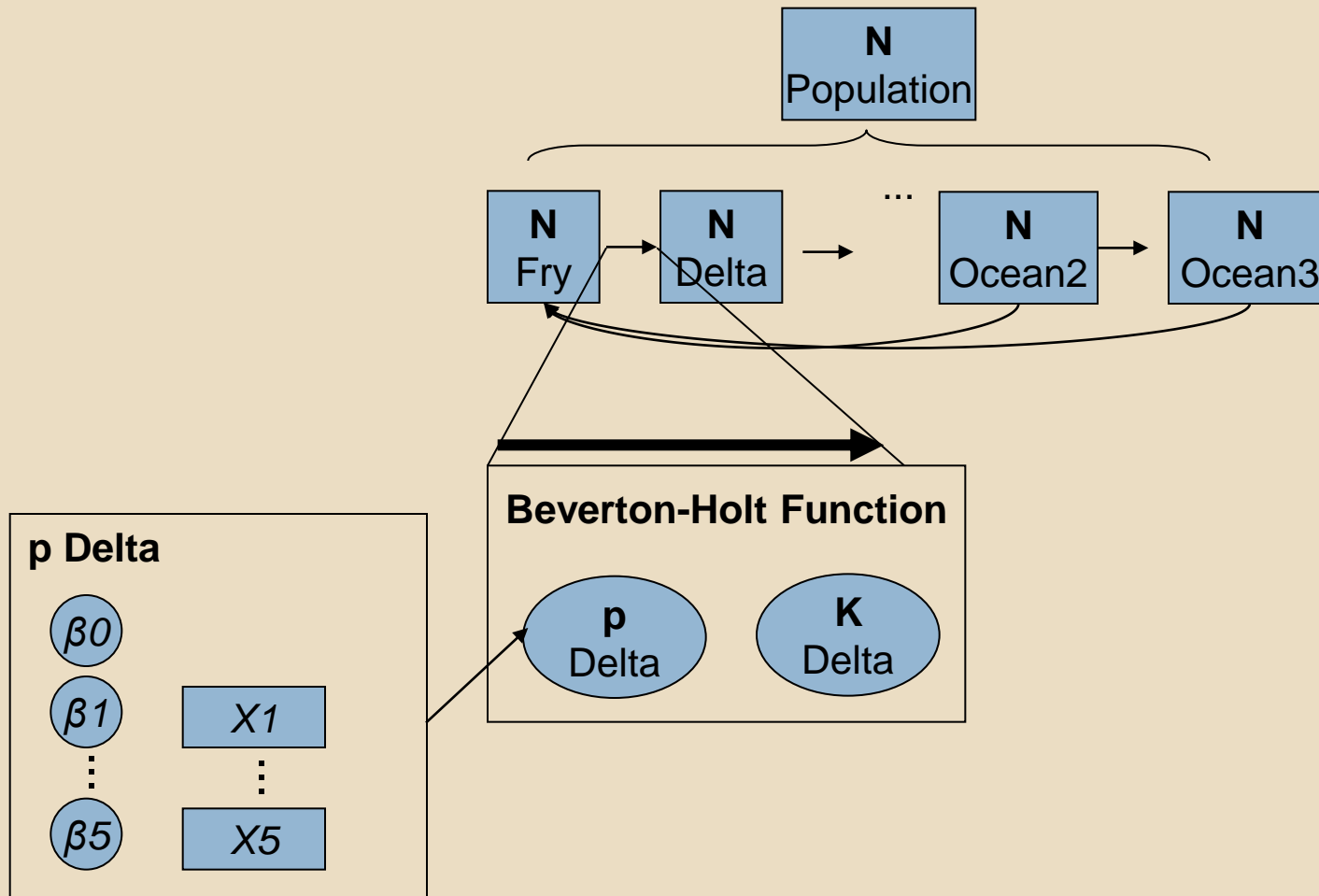
The parameters of the BH function may change over time

- $K = \text{capacity}$
 - ▣ Typically attributed to limitations in habitat quantity
 - ▣ E.g., diking and levee construction (decadal), floodplain habitat (annual)
- $p = \text{productivity}$
 - ▣ Survival in most stage transitions, attributed to habitat quality
 - ▣ E.g., temperature mortality

Incorporating environmental and anthropogenic factors

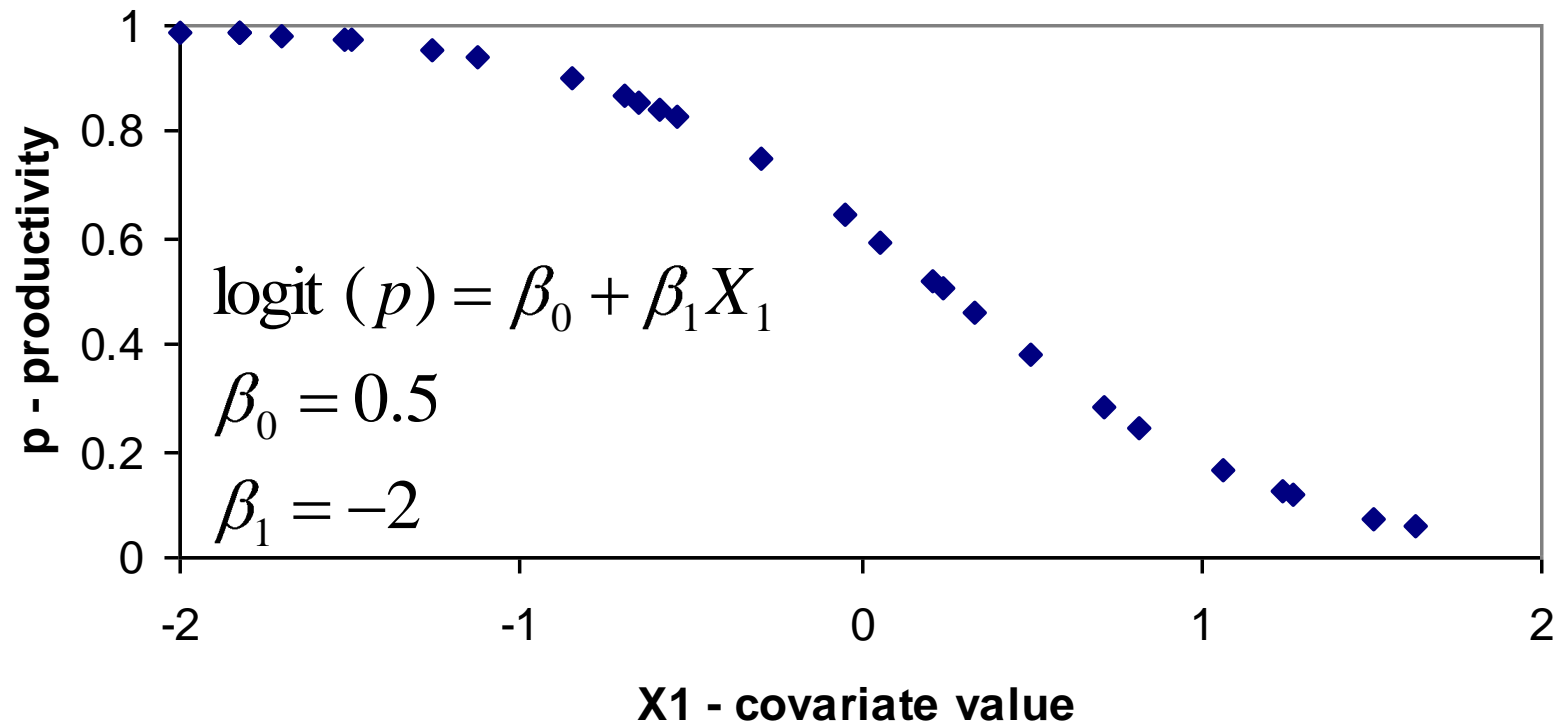
- Need to be able to tie changes in the environment or changes in the levels of a managed factor to the survival of a life history stage
- Create a second stage of the hierarchy so that the **p** and **K** parameters of the Beverton-Holt transition can be modeled

2nd Hierarchy: Modeling the BH parameter p

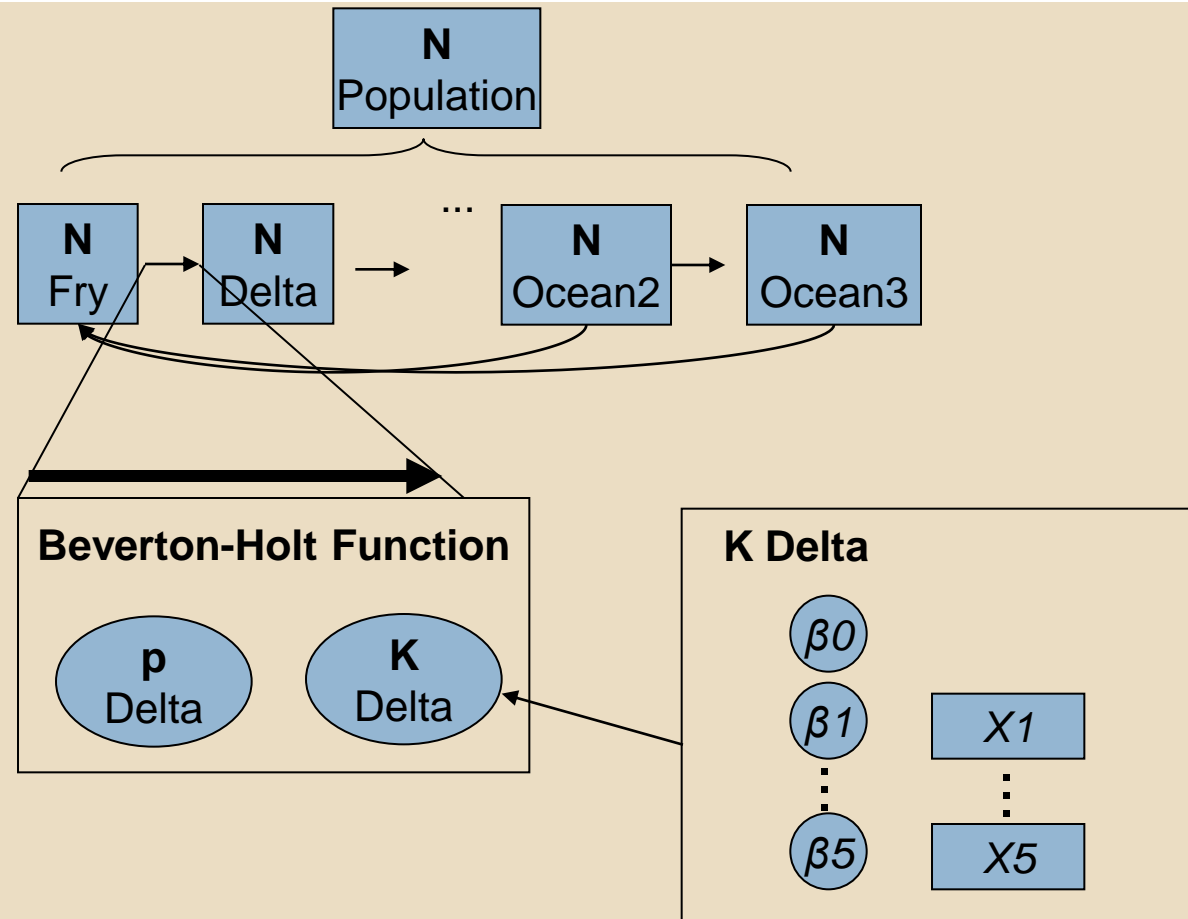


Modeling the BH p parameter

logit() transformation

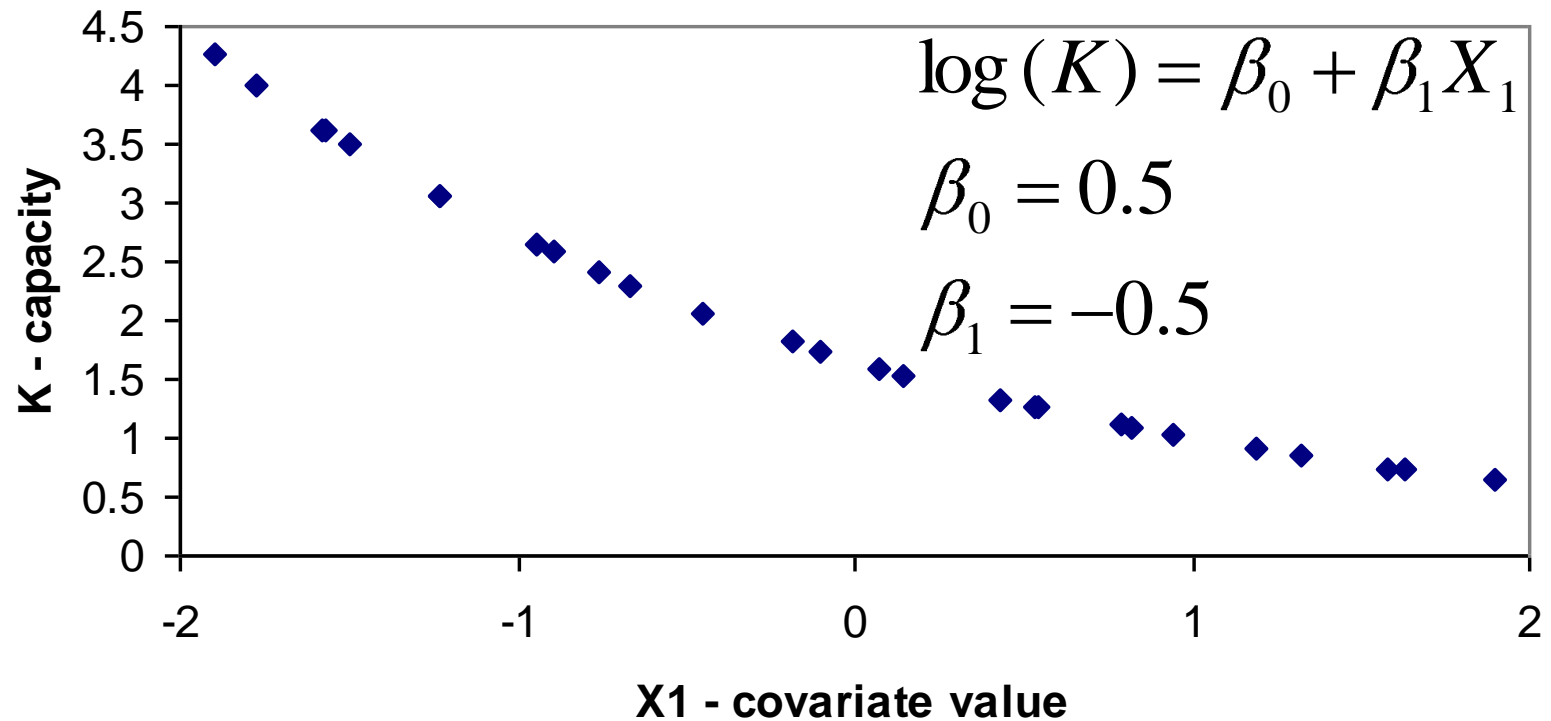


2nd Hierarchy: Modeling the BH parameter **K**

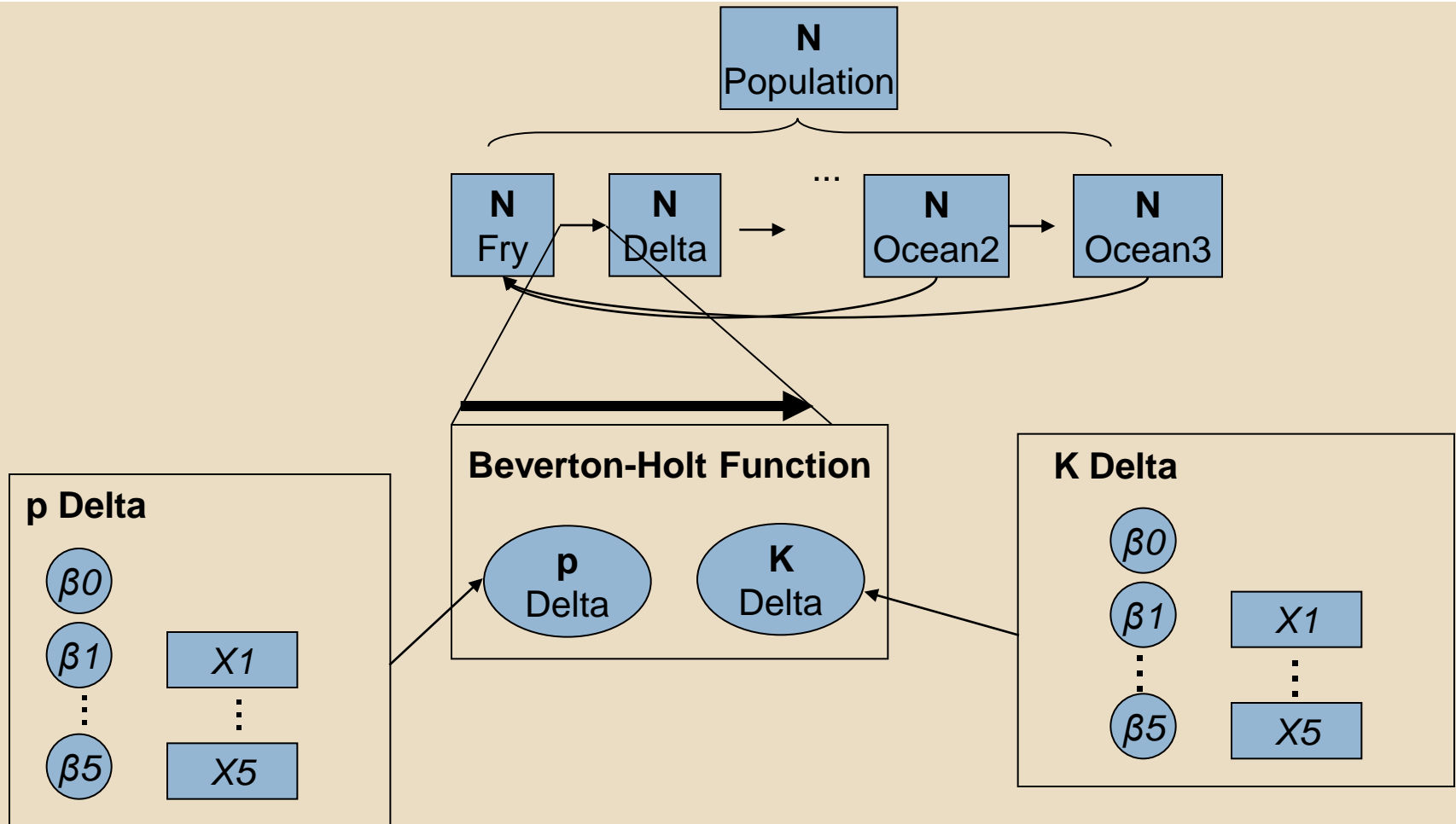


Modeling the BH K parameter

log() transformation



Full Hierarchy

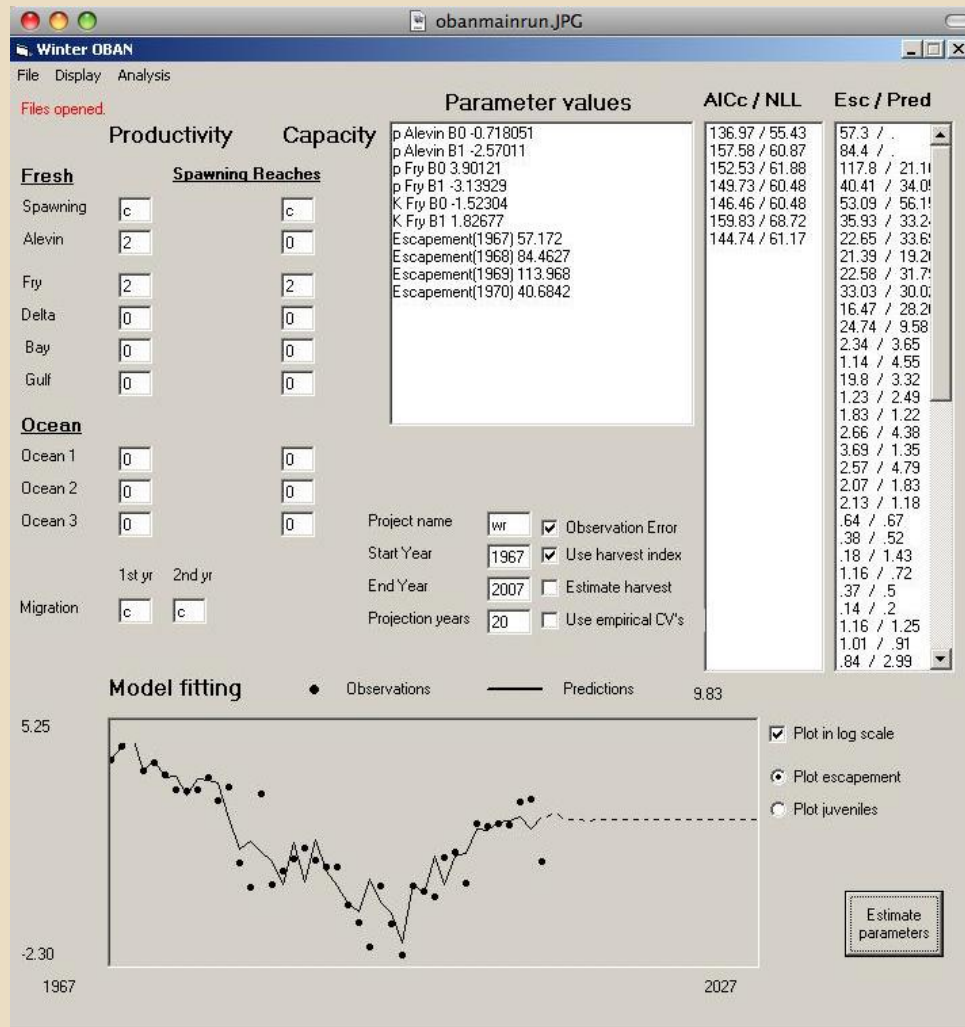


Winter Run Model details

- Period of retrospective analysis: 1967 – 2008
- Data
 - ▣ Annual escapement: 1967 – 2008
 - 1967 – 1987 counts conducted via a weir type setting
 - 1988 – 2001 expansion assuming 15% of the run after May 15th
 - 2002 – 2008 carcass surveys
 - ▣ Juvenile production indices: 1995 – 1999, 2002-2007
- Assumptions:
 - Harvest rates reflect relative levels of exploitation
 - Maturation rates from analysis of '98, '99, '00 CWT data

Winter Run Modeling Tool

OBAN-lite: stand alone software developed by UW and R2



- Delivers point estimates (MLE)
- Estimation is fast
- Stable and available to public
- Easy to convert competing hypotheses into model structural forms (GUI based)
- Easy to compare competing hypotheses with AIC

Winter OBAN

Bayesian estimation

- Covariates incorporated into Winter OBAN
 - ▣ Temperature in spawning reaches (alevin)
 - ▣ Minimum Flow at Bend Bridge (fry)
 - ▣ Exports, Yolo access (delta)
 - ▣ Curl upwelling index (gulf)
 - ▣ Harvest (ocean 2 and 3)



The Good Reverend
Thomas Bayes

$$p(\beta | y) = \frac{p(\beta) p(y | \beta)}{p(y)}$$

Non-informative Priors

- Beta coefficients in logistic regression for productivities (King et al. 2010)
 - ▣ $\beta \sim N(0, 0.5)$, such that $\sigma^2 = 2$
- Beta coefficients in log linear regression for capacities
 - ▣ $\beta \sim N(0, 0.001)$, such that $\sigma^2 = 1000$
- Measurement error standard deviations
 - ▣ $\sigma \sim Unif(0, 30)$

Informative Priors

□ *Conditional Maturation rates*

- Age 2 $\sim \text{Beta}(1,10)$, [95%CI: 0.002, 0.31]
- Age 3 $\sim \text{Beta}(10,1)$, [95%CI: 0.69, 0.99]
- Age 4 = 100%

▣ Consistent with Analysis of CWT 1998 – 2000 brood years (Grover, A. 2004)

- 0.01 – 0.17 Age 2 Maturation
- 0.96-0.97 Age 3 Conditional Maturation Rate
- 1.0 Age 4 Conditional Maturation Rate

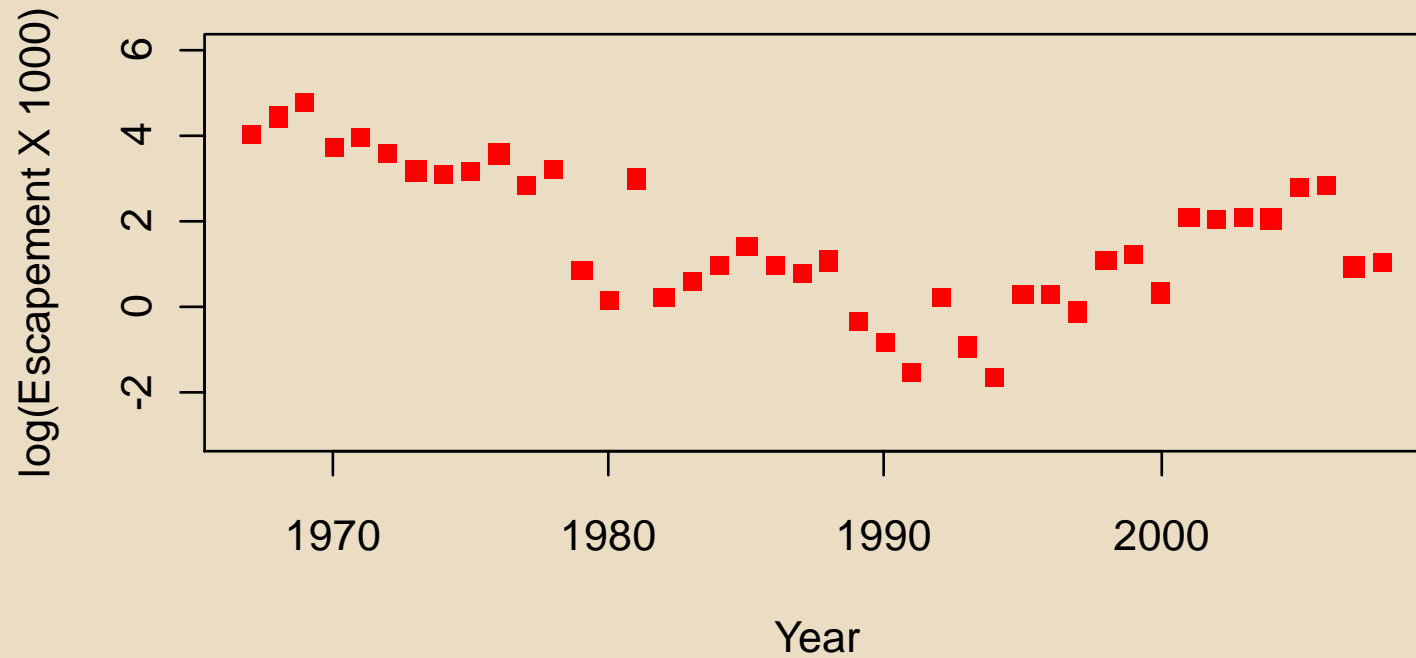
□ *Structuring of escapement measurement error*

$$\sigma_{\text{weir}} \leq \sigma_{\text{carcass}} \leq \sigma_{\text{expansion}}$$

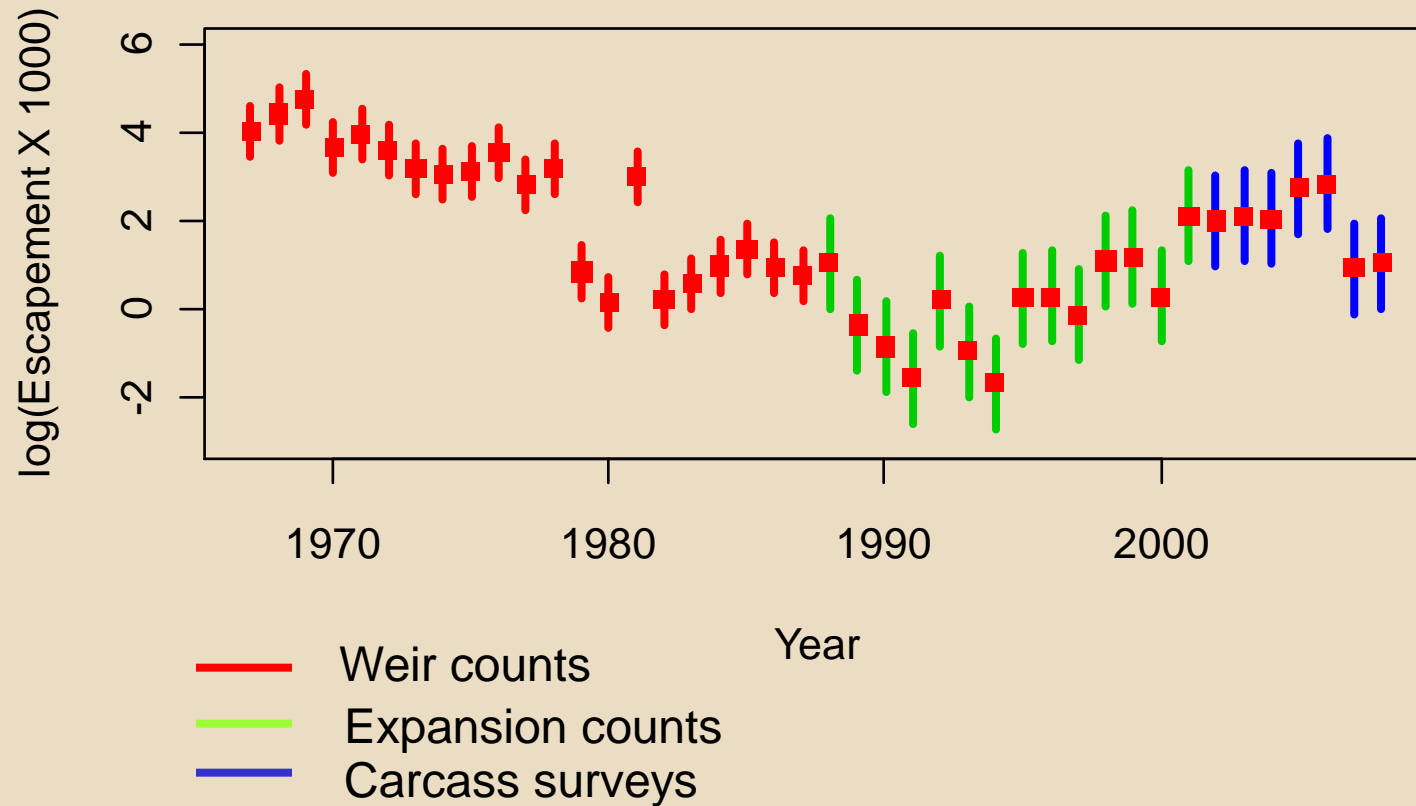
Bayesian estimation

- Model constructed in WinBUGS
- Implemented MCMC primarily via Distribution free adaptive rejection steps (log concave densities)
- Few opportunities for Gibbs sampling due to few conjugate priors being employed
- Ran 3 chains
- Evaluated lack of convergence with Brooks-Gelman-Rubin statistic (Brooks and Gelman 1998)
- 25,000 burn-in; 25,000 samples, thinned every 75 per chain

WR escapement

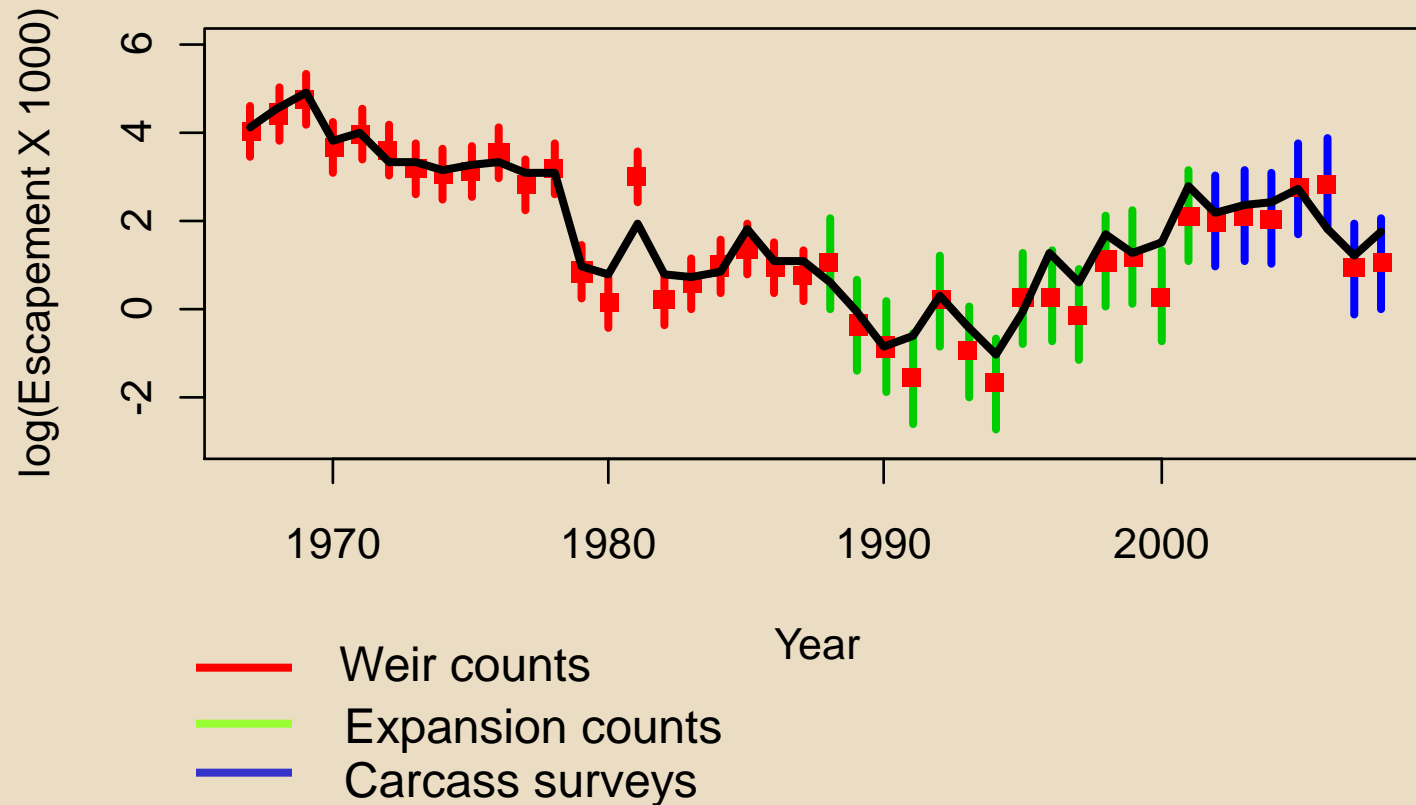


Escapement with measurement error



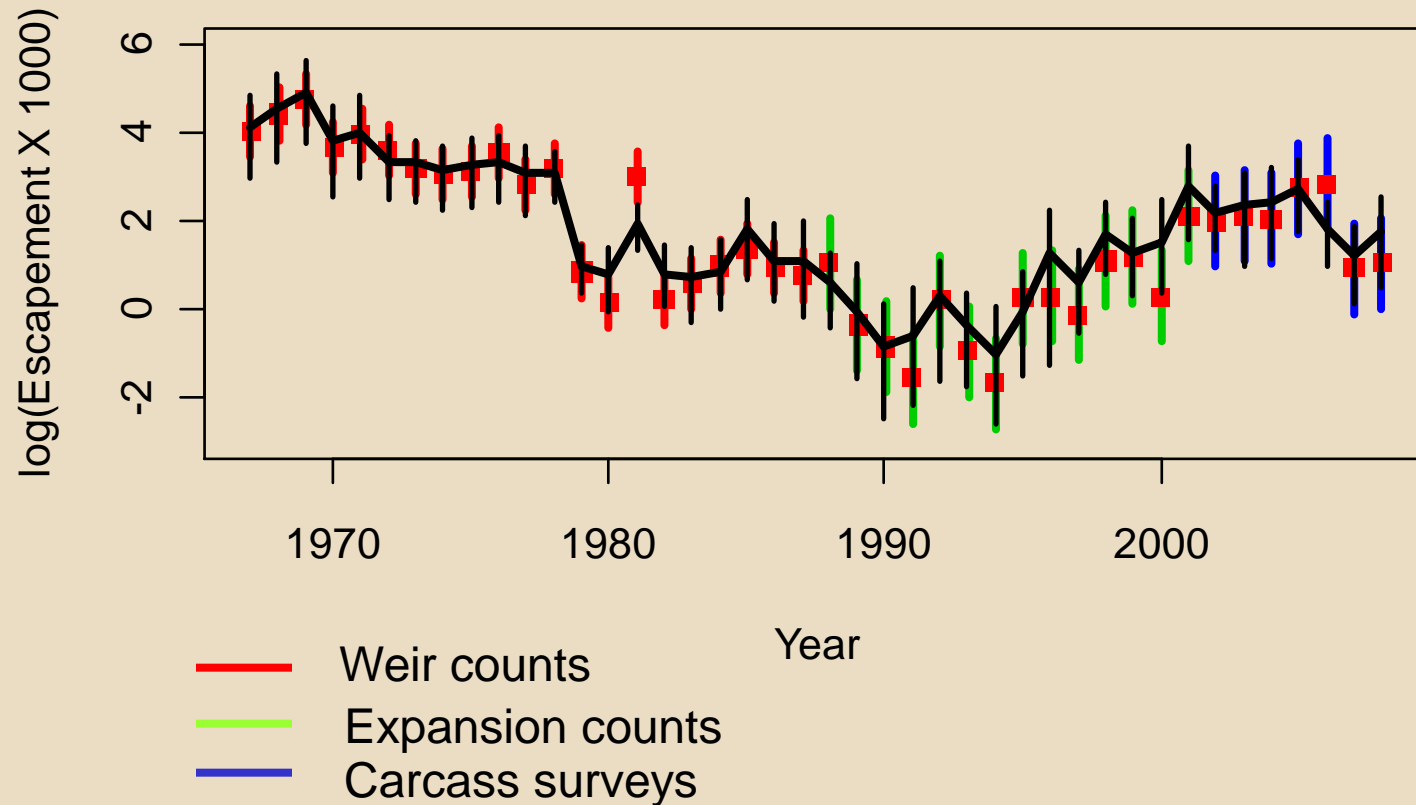
OBAN fit to WR escapement

mean predictions



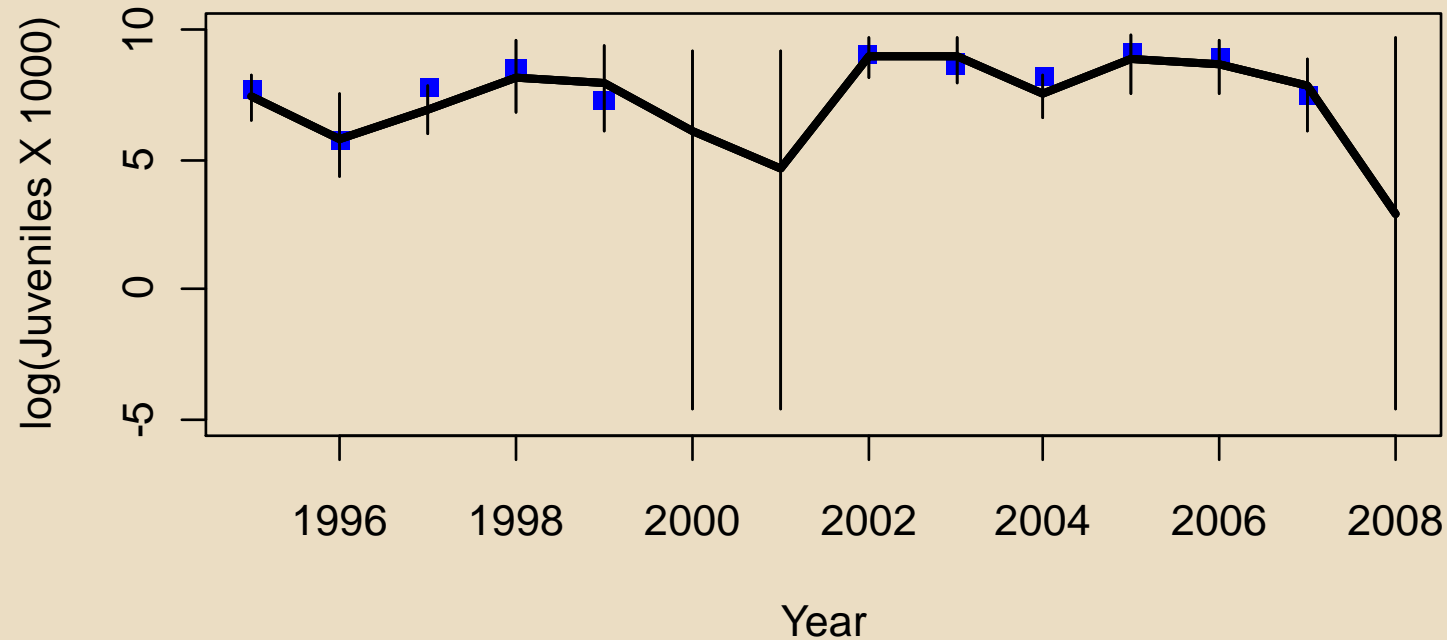
OBAN fit to WR escapement

mean predictions with 95% credible intervals

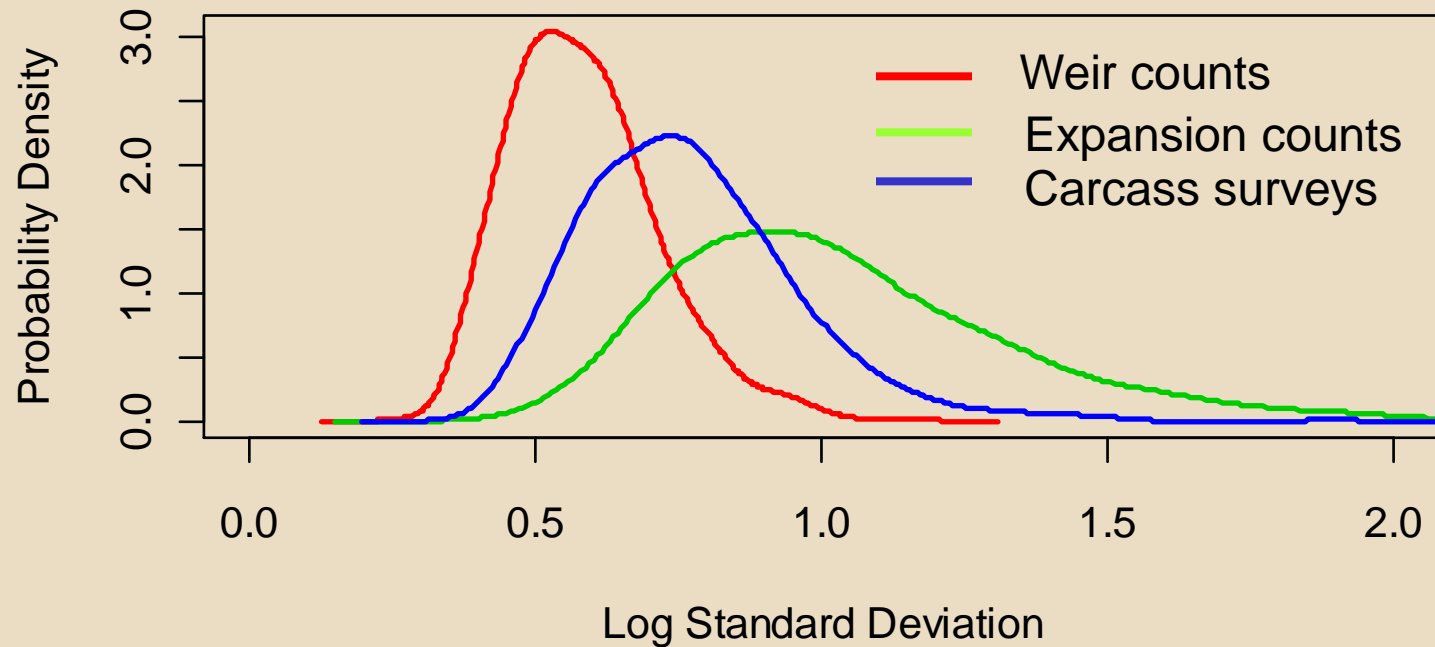


OBAN fit to juvenile counts

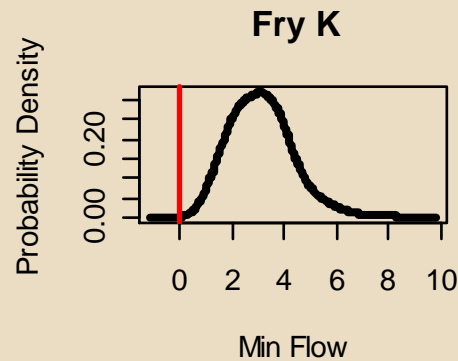
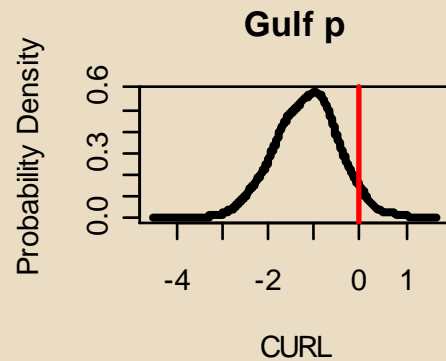
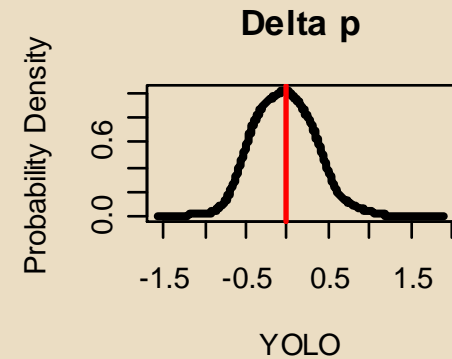
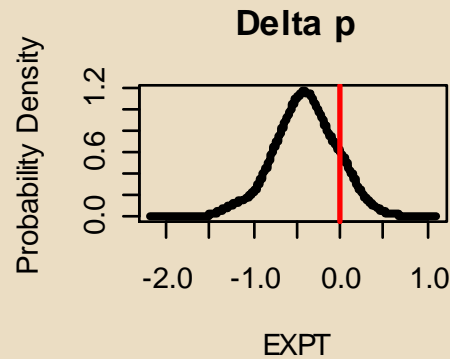
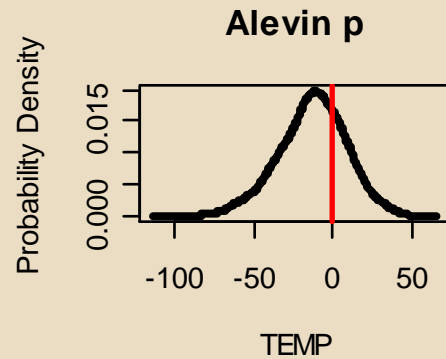
mean and 95% symmetric credible intervals



Measurement error estimates from different escapement data sources

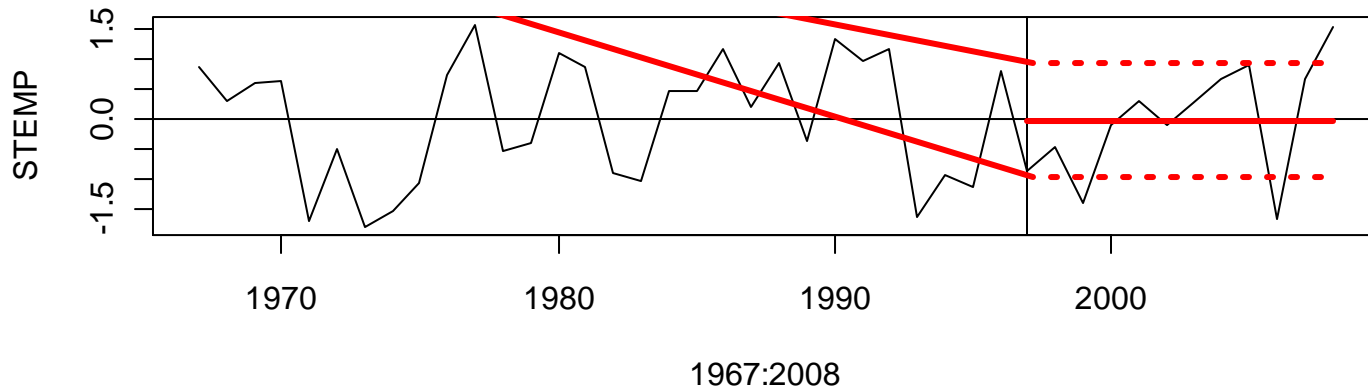


Posterior Distributions of Environmental Drivers

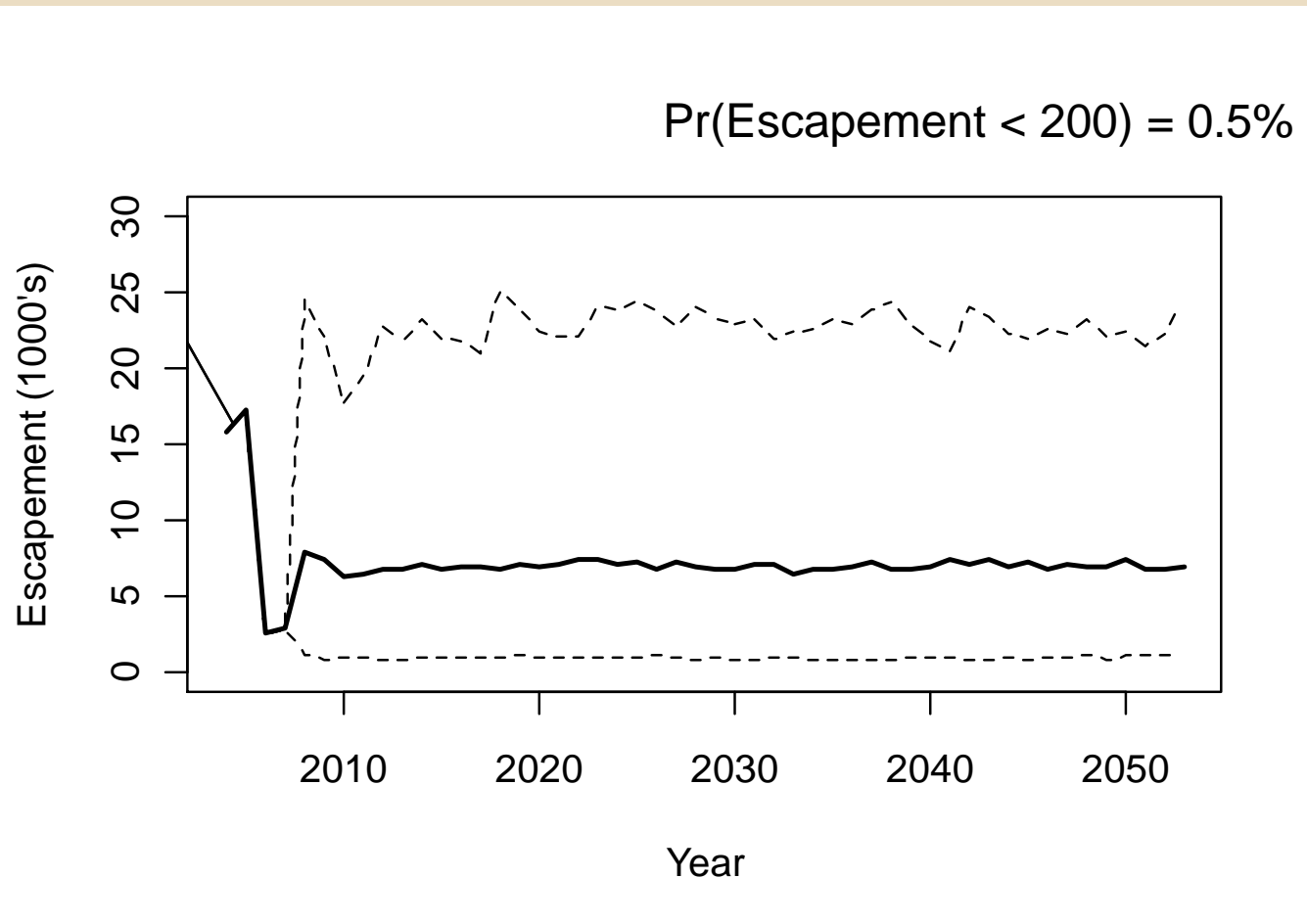


Population Viability Analysis

- Temperature in spawning reaches is random draw from Normal distribution with average (13.2 C) and standard deviation (0.9 C) from 1997 to 2008
- Harvest set at 0.27 (rate since 1997)

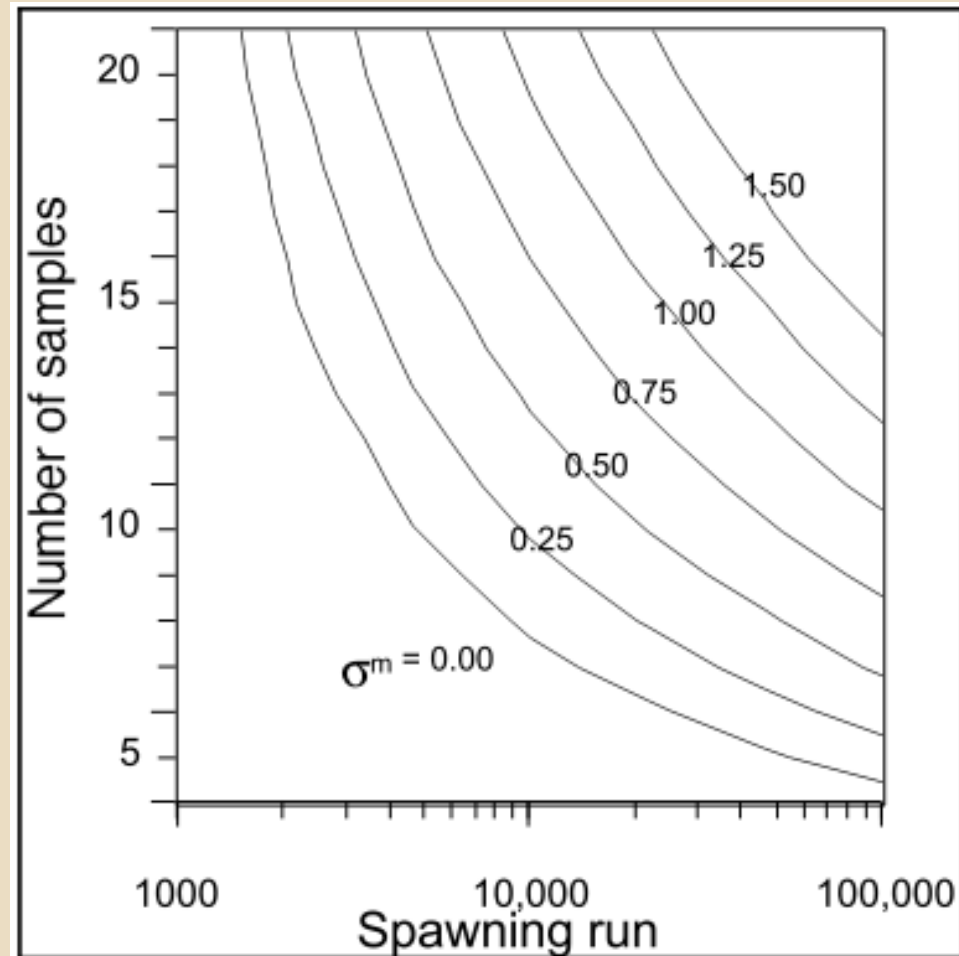


Escapement Forecast - 50 years



Next Steps – Winter Run

- Evaluate value of age structured return data
- Revisit Botsford and Brittnacher 1998 delisting criteria (Cons. Bio. 12:65)
 - ▣ 10,000 spawning females
 - ▣ 13 years of escapement estimates
 - ▣ Assuming 25% sampling error
 - ▣ leads to $\leq 10\%$ chance of quasi-extinction in 50 years



Next Steps - OBAN

- Spring-run and fall-run models
 - ▣ Spring-run model for Butte and Deer Creek completed in MLE framework
 - ▣ Fall-run model is focus of newly funded CALFED grant with UW
 - ▣ Incorporating hatchery impacts
- Delta specific models
 - ▣ Evaluation of potential for life-history diversity of fall, spring, and winter-run through habitat restoration of the Delta
 - ▣ Models being developed in SLAM with NMFS NWFSC and SWFSC

THANK YOU

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www.r2usa.com/oban